

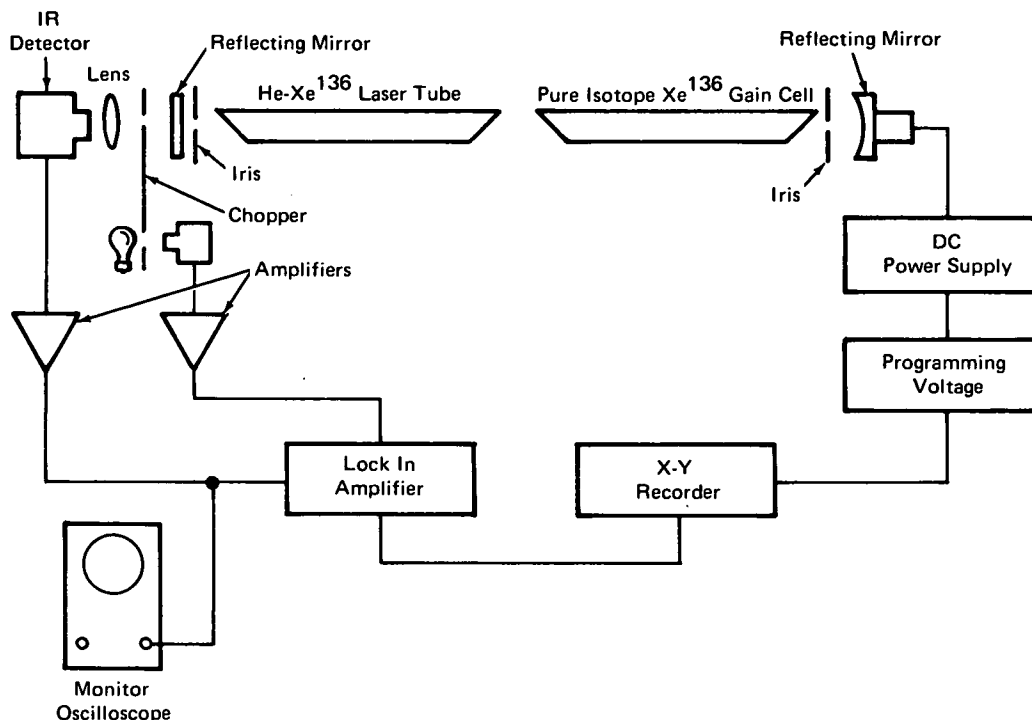
# NASA TECH BRIEF

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### Enhanced Lamb Dip for Absolute Laser Frequency Stabilization



#### The problem:

The inverted Lamb dip due to an absorbing cell inside a laser cavity can be used for improved frequency stabilization of the laser output. In previous experiments, this absorption was provided by either an organic gas compound producing absorption peaks near the laser frequency or a cell using the same atom as the laser, such as Ne in a He-Ne laser.

#### The solution:

An enhanced Lamb dip was observed in a He-Xe<sup>136</sup> laser oscillator that used an internal Xe<sup>136</sup> gain cell. As a result of this observation, it is estimated that frequency stabilization at 3.5  $\mu\text{m}$  to one part in  $10^{11}$  is possible by the use of this enhanced Lamb dip as a reference.

#### How it's done:

The block diagram of the enhanced Lamb dip He-Xe<sup>136</sup> laser with the pure Xe<sup>136</sup> gain cell is shown in the figure. The laser is a tube filled with 2 Torr of He and approximately 20 mTorr of single isotope Xe<sup>136</sup>. The Xe gain cell is a discharge tube filled with isotopic Xe<sup>136</sup> to a pressure of 5 mTorr. In both tubes, the Xe pressure is controlled by a liquid-nitrogen cooled pressure adjustment system, which allows the tubes to be operated over long lifetimes.

In this system, the He-Xe tube is rf excited, while the pure Xe gain cell is both rf and dc excited to maintain a uniform discharge. From the present configuration, single transverse mode operation is obtained by use of two apertures inside the laser cavity.

(continued overleaf)

The output power, as a function of laser frequency, is recorded in two steps. First, the curve is taken with the Xe gain cell turned off to show the pressure-broadened, slightly asymmetrical Lamb dip. The curve is then taken with the gain cell on, but with the laser output adjusted to the previous level to avoid power broadening effects.

Results show that the width of the enhanced Lamb dip is 5 MHz and the total depth is 10% of the peak power. Thus, the present configuration should be very useful as a frequency standard in the near infrared. With the appropriate feedback control, the laser can be stabilized to better than one part in  $10^3$  of the enhanced Lamb dip of 5 MHz, which can translate into the frequency stabilization of one part in  $10^{11}$  at 3.5  $\mu\text{m}$ . Furthermore, this technique can easily extend to other lasers, for which the low-pressure narrow-linewidth gain tubes can be constructed.

**Note:**

Requests for further information may be directed to:  
Technology Utilization Officer  
NASA Headquarters  
Code KT  
Washington, D.C. 20546  
Reference: TSP72-10481

**Patent status:**

No patent action is contemplated by NASA.

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